

## ***DIABROTICA CRISTATA*, A CHRYSOMELID (COLEOPTERA) OF RELICT MIDWESTERN PRAIRIES DISCOVERED IN EASTERN SERPENTINE BARRENS<sup>1</sup>**

A.G. Wheeler, Jr.<sup>2</sup>

**ABSTRACT:** *Diabrotica cristata*, a galerucine chrysomelid characteristic of relict prairie ecosystems in the Great Plains but seldom collected on the eastern seaboard, is reported from four serpentine barrens in southeastern Pennsylvania and one in adjacent Maryland. Large populations were present in two of the barrens, with adults collected from inflorescences of two grasses and from 17 species of forbs in 7 families. The larval host was not determined but is suggested to be little bluestem, *Schizachyrium scoparium*, a perennial grass dominant on serpentine soils, or the less abundant big bluestem, *Andropogon gerardii*, a known host of *D. cristata* in midwestern prairies.

*Diabrotica cristata* (Harris) belongs to the chrysomelid subfamily Galerucinae and tribe Luperini. It is a member of the *virgifera* group of the large New World genus *Diabrotica*, which in the United States includes the northern corn rootworm, *D. barberi* Smith and Lawrence; western corn rootworm, *D. virgifera virgifera* LeConte; and Mexican corn rootworm, *D. v. zea* Krysan and Smith (Branson and Krysan, 1981; Krysan and Smith, 1987).

Smith (1966) noted the association of *D. cristata* with wild grasses in the United States east of the Rocky Mountains and south onto the Mexican Plateau. But until recently biological information on this rather inconspicuous inhabitant of relict prairie ecosystems was scant, and the use of grasses as larval hosts remained unconfirmed. Problems in developing corn lines resistant to rootworms, however, focused attention on the noneconomic *D. cristata*. It was hoped that an increased knowledge of its habits might elucidate the evolution of host relationships among pestiferous species of the *virgifera* group and lead to better methods of managing their populations.

Wiesenborn and Krysan (1980) observed adults of *D. cristata* on flowers of various forbs, where they apparently feed on pollen. In their survey of relict prairies in eastern South Dakota and southwestern Minnesota, they found that big bluestem, *Andropogon gerardii* Vitman, usually was a good indicator plant for *D. cristata*, but that its presence did not always provide for a beetle population. Krysan (1982) hypothesized a tropical origin of the egg dormancy mechanism in this group of *Diabrotica*, which enabled the species to invade temperate North America and to specialize on perennial grasses, a predictable food resource but one of

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restricted availability. For *D. cristata*, complexity of prairie sod and small larval populations precluded the verification of grasses as host plants; thus, grasses had been only inferred as hosts until Yaro and Krysan (1986) found larvae feeding on roots of *A. gerardii* in South Dakota. In the laboratory, this species has been reared on roots of corn (Krysan and Smith, 1987).

Although *D. cristata* was originally described from Northampton, Massachusetts (see Smith and Lawrence, 1967), and is known from New Hampshire south to Georgia and Alabama (Krysan and Smith, 1987), specimens from eastern United States are generally scarce in collections (J.L. Krysan, pers. comm.). Krysan and Smith (1987) remarked that populations of nonpest species of the *virgifera* group are "highly localized within their overall ranges." Large numbers of *D. cristata* apparently have not been recorded along the eastern seaboard, and habitat preferences outside relict midwestern prairies are unknown.

The presence of *D. cristata* in eastern serpentine barrens, including large populations at two localities, is here reported. Serpentine barrens are unique habitats that harbor a characteristic flora associated with nutrient-poor, rocky soils and are only beginning to be appreciated for their interesting insect fauna. The number of adults collected in inflorescences of various forbs and grasses on several sample dates is also given.

## METHODS AND STUDY SITES

Following the discovery of *D. cristata* in a Pennsylvania serpentine barren, several eastern barrens were surveyed during late July to early September 1987 to determine the beetle's relative abundance and plant species used for adult feeding. Inflorescences of forbs and grasses were tapped into a small beating net and plant species harboring adults were recorded. On 8 Aug. the numbers of *D. cristata* taken in inflorescences of various plants during approximately 75 minutes of collecting at each of 3 serpentine barrens (Goat Hill, Nottingham Park, and Soldiers Delight) were recorded. Similar surveys of some of the same and additional barrens were made on 12 and 19 Aug. and 2 Sept. 1987. Voucher specimens of *D. cristata* have been deposited in the insect collections of Cornell University and Pennsylvania Department of Agriculture.

In addition, inflorescences of plants growing just outside (1-2 km) the well-defined limits of the Goat Hill and Nottingham Park barrens were surveyed for *D. cristata*. During studies of other insects, similar methods were used from late July to early September to try to detect populations in nonserpentine habitats in eastern Pennsylvania.

The serpentine barrens surveyed are outcrops of serpentinite, an ultramafic, often yellowish-green rock containing at least 50% hydrous

magnesium silicate. In eastern North America these barrens belong to a broken chain of isolated areas stretching from western Newfoundland and the Gaspé Peninsula to east-central Alabama; the best developed formations lie in the hilly, eroded easternmost portion of the Piedmont Upland in southeastern Pennsylvania and northern Maryland (Pennell, 1930; Miller, 1977; Reed, 1986).

Serpentine soils, although varying in chemical and physical properties from site to site, tend to be low in calcium (and often other nutrients), high in iron and magnesium, and sometimes also high in chromium, cobalt, and nickel. Soils usually are shallow, excessively dry, rocky and, owing mainly to toxic concentrations of heavy metals, low calcium levels, and to other adverse chemical and physical features, are unfavorable for agriculture. Vegetation developing on nutrient-poor serpentine soils is sparse, often stunted, and nearly always contrasts sharply from that of surrounding areas (Proctor and Woodell, 1975; Miller, 1977; Mansberg and Wentworth, 1984). Serpentine plant communities are thus characterized by endemism, disjunct ranges, ecotypic differentiation, and morphological variants (Proctor and Woodell, 1975; Mansberg and Wentworth, 1984). Recent work by Knox (1984) suggested that recruitment of forest communities is episodic rather than continuous and reflects regular disturbance of stands by fire or drought, which maintains the open habitat supporting a characteristic flora.

The following are brief descriptions of the serpentine areas surveyed. Additional information on plant communities of these and other eastern serpentine barrens is available in Harshberger (1903, 1904), Pennell (1910, 1930), Wherry (1963), Miller (1977), and Reed (1986).

Goat Hill Serpentine Barrens: southeastern Chester Co., Pennsylvania, along the Octoraro Creek southwest of Nottingham near the Maryland State line; one of the largest of the eastern serpentines, encompassing 700 acres (283 ha) of pitch pine (*Pinus rigida* Mill.) - scrub oak (*Quercus ilicifolia* Wang, and *Q. prinoides* Willd.) forest; thickets of greenbrier (*Smilax* spp.); localized blackjack and post oak (*Q. marilandica* Muenchh. and *Q. stellata* Wang.); parklike openings dominated by little bluestem or prairie beardgrass (*Schizachyrium scoparium* (Michx.) Nash) and other bunch grasses; and xeric rock and gravel outcrops characterized by the presence of serpentine aster (*Aster depauperatus* (Port.) Fern.) (Asteraceae), fame flower (*Talinum teretifolium* Pursh (Portulacaceae), and sandwort (*Arenaria stricta* Michx.) (Caryophyllaceae) (Pennell, 1910).

Nottingham Park Barrens: 645 acres (261 ha) west of Nottingham; like Goat Hill, belonging to the state line barrens and having diverse plant communities dominated by pine-smilax thickets, bare exposures with various "indicator" plants, and grassy openings, some with nearly pure stands of little bluestem.

New Texas (Lyles) Barrens: another of the state line group, 255 acres (103 ha) lying south of Wakefield in southern Lancaster Co. near Conowingo Creek; characterized by Virginia pine (*Pinus virginiana* Mill.), mixed oaks, eastern red-cedar (*Juniperus virginiana* L.), and large open areas of little bluestem and other grasses.

Rock Springs Barrens: 176 acres (71 ha) south of New Texas at Jenkins Corner just north of the Maryland line; the site of Miller's (1977) ecological study, consisting of Virginia pine-oak forest, open areas of little bluestem and other grasses, and other plant communities typical of eastern serpentines.

Pink Hill (Middletown) Barrens, Tyler Arboretum: about 20 acres (8 ha) (Godfrey, 1980) near Lima, Delaware Co., and a member of the Philadelphia District barrens (Reed, 1986); a relatively undisturbed area (Brooks, 1987) dominated by carpets of *Cerastium arvense* L. (Caryophyllaceae) and *Phlox subulata* L. (Polemoniaceae), stands of *Schizachyrium scoparium*, and scattered colonies of *Pycnanthemum tenuifolium* Schrad (Lamiaceae).

Unionville Barrens: a member of the Chester (Pennell, 1910) or West Chester District (Reed, 1986) and, like Pink Hill, separated from the state line group of barrens; 170 acres (69 ha) of pine-oak forest, dry upland thickets, open grassland, and other serpentine communities (Pennell, 1910) lying 1 1/2 miles northeast of Unionville (Wherry, 1963).

Soldiers Delight: an extensive serpentine outcrop of nearly 2,000 acres (800 ha) southwest of Reisterstown, Baltimore Co., Maryland, with diverse plant communities, including stands of Virginia pine, mixed oaks, openings of little bluestem and other grasses, and serpentine indicator plants (Godfrey, 1980; Knox, 1984; Reed, 1986; Brooks, 1987).

## RESULTS

During studies of Miridae and other Heteroptera in the Goat Hill barrens on 20 July 1987, I collected a *Diabrotica* sp. with which I was unfamiliar. After adults were determined as *D. cristata*, a chrysomelid seldom collected in the mid-Atlantic region, I returned to obtain additional specimens and make observations. On 23 July, 21 adults were collected from inflorescences of yarrow, *Achillea millefolium* L. (Asteraceae); numerous other adults were observed. Large numbers of beetles were taken on plant inflorescences in the Goat Hill (118 specimens) and Nottingham Park barrens (126) on 8 Aug. (Table 1), including a mating pair on Queen Anne's-lace, *Daucus carota* L. (Apiaceae). Cornfields are common in the farmland surrounding these barrens, and on many inflorescences adults of the northern corn rootworm, *D. barberi*, were also present. Much smaller numbers of *D. cristata* were found on 8 Aug. at Soldiers Delight, where

adults were observed only on inflorescences of plants growing near a stream: the composites *Eupatorium fistulosum* Barratt (1 adult), *Liatris spicata* (L.) Willd. (1), *Solidago juncea* Ait. (1), and *Vernonia noveboracensis* (L.) Michx. (3).

On 12 Aug., *D. cristata* was collected in serpentine barrens at Unionville and New Texas. At Unionville small numbers of beetles were observed on the composites *Cirsium muticum* Michx. (3 adults) and *Eupatorium fistulosum* Barratt (3); 6 adults were observed on another composite, *Solidago juncea*, at New Texas. No adults of *D. cristata* were collected during extensive sampling at the Pink Hill barrens on 12 Aug. Four adults were observed on *E. fistulosum* inflorescences at New Texas during additional surveys on 19 Aug., and only 1 adult, on *S. juncea*, was collected at Rock Springs. Plants from which *D. cristata* was collected in return trips to the Nottingham Park barrens on 19 Aug. and 2 Sept. are listed in Table 1. No additional adults were taken at New Texas on 2 Sept.

Large numbers of *D. cristata* also were observed on inflorescences of the composites *C. muticum*, *Eupatorium perfoliatum* L., *Helianthus helianthoides* (L.) Sweet, and *Rudbeckia laciniata* L. within 2 kilometers of the Nottingham Park barrens on 12 Aug. Otherwise, this chrysomelid was scarce or absent on plants adjacent to serpentine barrens. No adults were collected in nonserpentine habitats in Pennsylvania.

## DISCUSSION

*Diabrotica cristata* was present at five of the six serpentine barrens surveyed, with large populations found at Goat Hill and Nottingham Park and much smaller numbers at New Texas, Soldiers Delight, and Unionville; only Pink Hill proved negative for the beetle. Similarly, Wiesenborn and Krysan (1980) reported an irregular distribution for *D. cristata* in the northern Great Plains: abundant in some relict prairies but present in small numbers or absent in other prairies of similar vegetation. At Goat Hill and Nottingham Park the beetles were particularly numerous in inflorescences of dwarf sumac (*Rhus copallina*), joe-pye weed (*Eupatorium fistulosum*) and yarrow (*Achillea millefolium*). These plants (and certain others listed in Table 1) may represent preferred sources of pollen, but those yielding adults could merely have been common species that were in bloom and were encountered during the 75-minute surveys. Adults were taken in inflorescences of some of the same plant genera from which *D. cristata* was collected in the northern Great Plains: *Andropogon*, *Asclepias*, *Cirsium*, *Liatris*, *Rhus*, *Rudbeckia*, and *Solidago* (Kirk and Balsbaugh, 1975; Wiesenborn and Krysan, 1980). *Diabrotica cristata* and *D. barberi* are unique among species of the *virgifera* group in using a diverse group of forbs for adult

feeding rather than specializing on cucurbits (Yaro *et al.*, 1987), although both will feed compulsively on cucurbitacins in laboratory assays (see Krysan and Smith, 1987).

Grasses serving as larval hosts of *D. cristata* in mid-Atlantic serpentine barrens were not determined, but *Andropogon gerardii*, the only grass known to be a host in midwestern prairies (Yaro and Krysan, 1986), occurs at Nottingham Park (T.L. Smith, unpubl. data) and Soldiers Delight (Godfrey,

Table 1. Numbers of *Diabrotica cristata* adults collected from plant inflorescences in two serpentine barrens during summer 1987; see Methods and Study Sites for details of survey techniques and descriptions of habitats.

Taxa	Goat Hill	Nottingham Park		
	8 Aug.	8 Aug.	19 Aug.	2 Sept.
Anacardiaceae				
<i>Rhus copallina</i> L.	7	60	- <sup>a</sup>	-
Apiaceae				
<i>Daucus carota</i> L.	1	10	-	-
Asclepiadaceae				
<i>Asclepias verticillata</i> L.	1	-	-	-
Asteraceae				
<i>Achillea millefolium</i> L.	8	35	-	-
<i>Ambrosia artemisiifolia</i> L.	-	-	-	-
<i>Cirsium muticum</i> Michx.	-	9	5	3
<i>Eupatorium aromaticum</i> L.	-	1	-	-
<i>E. fistulosum</i> Barratt	92	-	8	-
<i>E. perfoliatum</i> L.	-	-	7	-
<i>E. rugosum</i> Houtt	-	3	-	-
<i>Heliopsis helianthoides</i> (L.) Sweet	3	-	-	1
<i>Solidago juncea</i> Ait.	4	-	1	-
<i>S. nemoralis</i> Ait.	-	-	-	7
<i>Vernonia noveboracensis</i> (L.) Michx.	-	1	-	-
Lamiaceae				
<i>Pycnanthemum tenuifolium</i> Schrad.	1	6	-	-
Poaceae				
<i>Andropogon gerardii</i> Vitman	-	-	3	-
<i>Setaria faberi</i> Herrm.	-	1	-	-
Phytolaccaceae				
<i>Phytolacca americana</i> L.	1	-	-	-
Rosaceae				
<i>Spiraea latifolia</i> (Ait.) Borkh.	-	-	2	-
Totals	118	126	27	11

a: Plant in pre- or post-bloom stage and therefore not sampled, or blooming but not encountered during c. 75 min. of survey.

1980). *Schizachyrium scoparium* (formerly in *Andropogon*), however, is a dominant plant of eastern serpentine barrens (Pennell, 1910; Stone, 1945; Braun, 1950) and a likely larval host plant of *D. cristata*. Godfrey (1980) noted that *S. scoparium* apparently is tolerant of heavy metals occurring in serpentine soils, has modest demands for nutrients, and benefits from the exclusion of competing plant species.

*Diabrotica cristata* has been recorded from widespread localities along the eastern seaboard (Krysan and Smith, 1987). Although several correspond well to the distribution of ultramafic rocks mapped by Reed (1986) and Brooks (1987), *D. cristata* obviously is not restricted to such outcrops. But east of the main Prairie Province (see Smith, 1957), which has isolated communities extending as far east as northwestern Pennsylvania (Transeau, 1935), some of the largest populations appear to occur in serpentine barrens. These relatively undisturbed islands in the eastern deciduous forest or in surrounding farmland have distinctly midwestern grassland communities that develop in parklike openings. Three of the "big four" of tall grass prairies — *A. gerardii*, *S. scoparium*, and Indian grass, *Sorghastrum nutans* (L.) Nash (Gould, 1975) — occur in many eastern serpentine barrens. Other grasses of midwestern plains and prairies that are present include *Aristida dichotoma* Michx., *Bouteloua curtipendula* (Michx.) Torr., and *Sporobolus heterolepis* (A. Gray) A. Gray (Pennell, 1910; Godfrey, 1980; Brooks, 1987; T.L. Smith, unpubl. data). In my survey of the eastern serpentine barrens, adults of *D. cristata* were confined to serpentine outcrops or were observed only in inflorescences of forbs growing at the periphery of these well-defined habitats.

Several authors, namely Proctor and Woodell (1975), Kruckeberg (1984), and Brooks (1987), have emphasized the dearth of ecological information available on insects and other animals associated with serpentine soils. Kruckeberg pointed out that the unique substrate should "be expected to harbor unusual faunistic features."

Five species of skippers (Lepidoptera: Hesperiiidae) known to develop on *Schizachyrium scoparium* in barren habitats appear also to be intimately associated with this grass; these species either occur frequently in or are restricted to such areas in a portion of their range (Opler and Krizek, 1984). For *Hesperia metea* Scudder and *Atrytonopsis hianna* (Scudder), hesperiids for which substantial ecological and distributional data were lacking, Shapiro (1965) reported a close relationship with *S. scoparium*; neither skipper occurs in situations where little bluestem is not dominant or where it is only a short-term member of the vegetation. In southeastern Pennsylvania these hesperiids and their host reach maximum abundance on "dry, open hillsides," but they may be found in other areas of

the state where little bluestem is a dominant component of the vegetation (Shapiro, 1965).

On the eastern seaboard the chrysomelid *D. cristata* becomes numerous in several serpentine barrens and could be expected to occur in nonserpentine habitats dominated by *S. scoparium*, for example, the New Jersey Pine Barrens (Shapiro, 1965). In the mid-Atlantic region it might be present in small numbers where little bluestem colonizes temporarily as an early successional species. *Diabrotica cristata* might also occur on the poor, rocky soils of New England where, according to Shapiro (1965), more permanent stands of this grass tend to develop. Specifically, this chrysomelid should be looked for near its type locality, Northampton, Massachusetts, where colonies of little bluestem occupy ridges of the nearby Mount Tom Range (B. Sorrie, pers. comm.).

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